

OBJECT-ORIENTED STRATEGIES

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OBJECT-ORIENTED DATABASE MANAGEMENT SYSTEM PRODUCTS

Object-oriented database management systems (OODBMSs) are a hot topic. A number of companies released commercial OODBMS products during the mid- to late 1980s and others will be releasing products in the years ahead. In the January issue of *OOS* we provided a general overview of OODBMS technology. In this article we consider some of the OODBMSs that are now on the market.

The market is too new for us to talk about which vendor has established the dominant position. Moreover, all of the OODBMS vendors are being challenged by the relational database vendors, who are extending their tools to handle objects. By next year we will have a better insight into which vendors are likely to prevail and prosper. At the moment, there are a large number of OODBMS vendors competing for the attention of anyone who will consider using an OODBMS. We'll begin by providing an overview of each of the better-established

OODBMS vendors and then compare and contrast their products in the following section.

A Quick Review

Figure 1 provides an overview of the architecture of an OODBMS. There are three key parts of any OODBMS: 1) the **data modeling and manipulation language (DMML)** environment where object data structures are created, accessed, and manipulated; 2) the **static storage medium** and the associated processes that put the data on disk, control updates, etc.; and 3) the **interface**, which allows the database developer to create the database and applications that provide end users with access to the data. We discussed the concerns that OO database users would have about each of these three areas in the last issue of *OOS*. In reviewing each of the OODBMS products in this issue, we consider how each product handles each of these three areas, in addition to the product's platform, pricing, and general vendor information.

OODBMS Vendors and Their Products

We'll consider each of the OODBMSs currently sold in the US and then compare and contrast them. Table 1 contains an outline of the features listed below.

G-BASE (version 4.3)

G-BASE is sold by Object Databases, a French-owned company that has its US offices in Cambridge, Massachusetts, USA. (Object Databases is owned by Graphael, a French CAD/AI vendor owned by COGEMA.) G-BASE was one of the earliest

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OODBMSs to market, having been launched in 1986. Originally written in Lisp and designed to work with Graphael's CAD offerings, G-BASE has been revised and is now written in C++. In addition, a new product based on the G-BASE technology will be announced at the March DBEXPO show in San Francisco, California, USA (see Calendar). The new product's name has not yet been announced. We will consider only the current version of G-BASE (4.3) at this time.

G-BASE's DMML object model is based on a language-independent semantic data paradigm that works with any language that supports external calls, but especially with C and C++. The DMML supports multiple inheritance and complex (but not composite) objects. It also offers limited schema modification capabilities.

A standard two-phase commit approach is used for transaction processing. G-BASE supports versioning, and historical versions can be accessed without locking. The interface for G-BASE is via X-Windows/Motif. A query language is provided, as is a 4GL capability. See Table 1 for a description of the hardware platforms G-BASE runs on. The product sells for \$25,000 to \$100,000.

G-BASE is supported by a large French corporation and thus has more financial resources than some of the other vendors. It seems determined to adopt its product in response to market demands.

GemStone (version 3.0)

GemStone is sold by Servio Logic Corporation (Servio), which is located in Alameda, California. Gemstone is written in C. Its data modeling capability is based on an extended Smalltalk-like

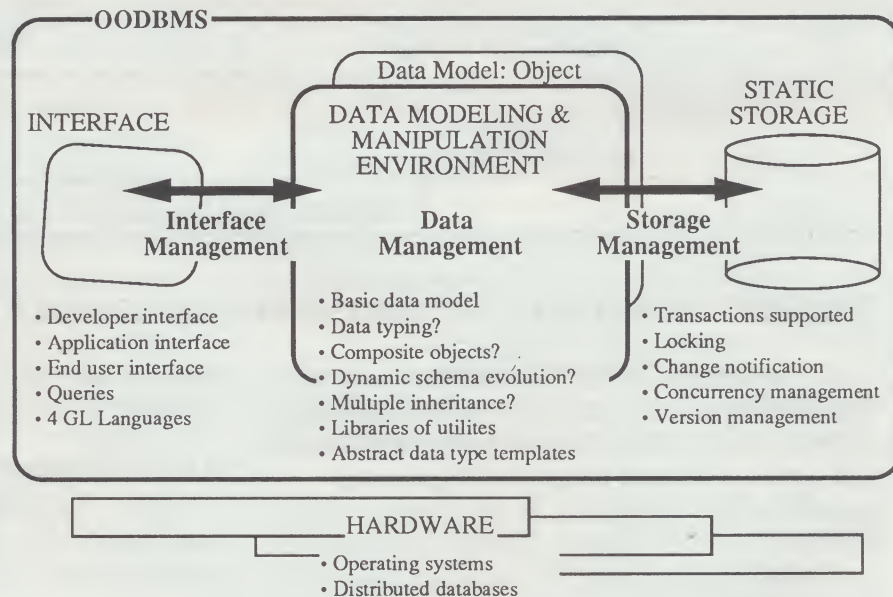


Figure 1 — An overview of an object-oriented database management system.

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model of an object. GemStone can interact with programs written in C, C++, and Smalltalk, and it provides C++ and Smalltalk class libraries. Within the GemStone data modeling environment, all data are represented as objects and are not strongly typed. Type checking is done at runtime. Like Smalltalk, which forms the basis for its DMML, GemStone does not support multiple inheritance or composite objects. It does, however, provide an interactive environment that makes schema modifications possible.

GemStone supports access to relational databases and distributed application execution within a heterogeneous networked environment. GemStone transactions are serialized and can be controlled via different locking modes. Objects are persistent. Referential integrity is enforced and backup can be full or incremental. GemStone does not provide version management or change notification.

GemStone provides a visual 4GL language, GeODE (GemStone Object Development Environment), which includes a code-free visual program-

ming environment, a visual schema designer, and a multimedia forms package. Applications in GemStone are portable across several platforms and operating systems. It has its own optimized object query language and provides password security.

GemStone runs on a wide variety of platforms (see Table 1). A single copy for the Sun 3 costs \$5,000. Servio is an IBM business partner, and Booz Allen provides GemStone training and consulting. GemStone is integrated with ParcPlace's ObjectWorks/C++.

Servio is one of the older OODBMS companies. It started with a system built around Smalltalk, which provided a more dynamic environment than C++. (Smalltalk is about midway between a static language like C++ and a really dynamic language like Lisp. Smalltalk, however, has some limitations, e.g., the lack of multiple inheritance, that make it less flexible than either C++ or Lisp.) As C++ evolved and became the *de facto* OOL standard, however, GemStone was revised in the direction of C++ to increase its efficiency and make it more widely acceptable.

IDB Object Database (version 1.1)

IDB Object Database is a newly released OODBMS sold by Persistent Data Systems, Inc., a company with offices in Pittsburgh, Pennsylvania, USA. The product is written in C and the DMML is a proprietary environment. The OODBMS is designed to interact with C. The model supports multiple inheritance and dynamic linking and loading of schema and operations. Transactions are serialized, three locking modes are available, and transactions can be nested. The system supports versioning and garbage collection, but does not support change notification.

The user interface is portable, with interactive browsers that run on a variety of different platforms (see Table 1). The cost of a single unit of IDB Object Database for a PC or Mac is \$2,500.

IDB Object Database has just been released and sounds somewhat limited; it is designed to help C

programmers who want to do object-oriented work, even though most programmers who are interested in OO technology are working in C++. It does offer a number of interesting features and is one of the least expensive products.

ITASCA (version 2.0)

ITASCA is sold by Itasca Systems Inc., which is headquartered in Minneapolis, Minnesota, USA. ITASCA is written in a combination of C and Lisp, and the DMML is essentially an interpreted Lisp environment. ITASCA provides interfaces for C, C++, and Lisp. Objects created using one language can be used with other languages. In addition, ITASCA also dynamically loads C and Fortran into ITASCA methods.

Within ITASCA data typing is optional. The object model is very rich, supporting multiple inheritance and extensive composite objects. In addition, ITASCA supports extensive dynamic schema modification without shutting down the database. The system provides libraries of utility classes, sets, collections, etc. ITASCA also provides support for audio and visual objects, and for short, long, and shared transactions. Persistent and nested transactions are serialized. Extensive locking on the object level is provided. ITASCA also features passive and active change notification, as well as elaborate and extensible versioning. The product supports shared, distributed, and individual databases. Methods can be stored in the database as part of the schema. The ITASCA GUI is built in OSF/Motif and includes dynamic schema and data editors. A custom query language allows "query by example." ITASCA has no 4GL capability. Extensive security is provided.

ITASCA runs on a number of different platforms (see Table 1). A single unit for a Sun 3 costs \$3,995. ITASCA is a commercial version of Orion, an OODBMS originally developed by MCC. Orion is available to MCC partners. Control Data has a minority interest in Itasca.

ITASCA is a Lisp-based OODBMS designed to run in a C/Unix world. In terms of DMML

Table 1 — Commercial Object-Oriented Database Management Systems

OODBMS Products and Vendors	Data Management			Storage Management
	Implementation Language	DMML	Data Modeling Support for:	Support for:
G-BASE (version 4.3) Object Databases Inc. 228 Broadway Cambridge, MA 02139 (617) 354-4220	C++	• Language-independent semantic data model • Easily interfaces with C and C++	• Any language supporting external calls • Any object model through subclasses of metamodel • Multiple inheritance • No multimedia support	• Standard two-phase commit approach for online transaction processing • Access to historical version without locking • Fault tolerance via object request • Supports heterogeneous classes
GemStone (version 3.0) Servio Corp. 14220 Harbor Bay Parkway, Suite 100 Alameda, CA 94501 (800) 243-9369	C	• Extended Smalltalk • C • C++ • Gemstone visual programming language	• OPAL — extended Smalltalk-like paradigm • Limited schema evolution facilities • All data types are objects • Not strongly typed • Type checking at runtime • No composite objects • No multiple inheritance • Provided Smalltalk and C++ class libraries • Access to relational DBs	• Serialized transactions • Persistent objects • Three locking modes: read, write, and exclusive • No version management • No change notification • Online full and incremental backup • Multi-policy versioning • Optimistic concurrency control
IDB Object DB (version 1.1) Persistent Data Systems 75 West Chapel Ridge Road Pittsburgh, PA 15238 (412) 963-1843	C	• C/IDL schema specification language • Implementations of operations written in C • Data access via API in C	• Multiple inheritance • Dynamic loading/linking of schema and operations • Unique IDs for all objects • ASCII form import/export of all objects	• Nested transactions • Read-only update • Persistent and nonpersistent • Three locking modes: examine, read, write • Transactions serialized • Versioning supports history and parallel alternatives • Storage allocator, garbage collection • No change notification
ITASCA (version 2.0) Itasca Systems, Inc. 7850 Metro Drive Suite 300 Minneapolis, MN 55425 (612) 851-3155	C and Common Lisp	• C or Common Lisp • Interfaces for C, C++, and Lisp • Dynamically loads C or Fortran into ITASCA methods • Multiple languages: object created using one language can be used with other languages	• Datatyping optional • Library of utility classes, sites, collections, etc. • Complex, extensive composite objects • Multiple inheritance • Multimedia support • Dynamic schema modification w/out shutting down the DBMS • Refinement of kernel methods on a class basis	• Short, long, and shared transactions • Persistent nested transactions serialized • Elaborate locking on object model • Passive and active change notification • Elaborate/extensible versioning • Application can be converted to multiple DBs at any time • Shared, distributed, and private DBs • Fully distributed with complete location transparency • Methods can be stored in DB as part of schema • Methods execute in DB server allowing multiple language execution
O₂ (Version 3.2) O ₂ Technology 7 rue du Parc de Clagny 78035 Versailles, France +33 1 30 84 77 77 1 Kendall Square Suite 2200 Cambridge, MA 02139 (617) 621-7041	C/C++ (2.1)	• C, C++ (2.1)	• Generic collection constructors: set, list (flexible insertable array), bag • Strongly typed • Complex values and objects • Multiple inheritance • Covariance of attributes and methods parameters • Referential integrity • Multiple schemas and DBs • Multimedia support	• Persistent and nonpersistent transactions serialized • Read-only transactions • Two locking modes: read, write • DB administrator mode: no-lock • Index management for collection of complex values • Cluster management • Versioning

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Table 1, continued — Commercial Object-Oriented Database Management Systems

Product	Interface Management	Hardware Platforms Supported and RAM Requirements	Pricing	Comments/Fielded Applications
G-BASE (continued)	• C++/X-Windows/Motif • Query language • 4GL capability • Semantic data model schema editor	• Sun SPARCstation • DecStation (VAX/VMS) • Min. RAM requirements: 16MB	\$25,000- \$100,000	G-BASE Technology is now available in an open-systems C++ environment. Object Databases owned by Graphael, a French CAD/AI company. New product based on G-BASE will be announced soon.
GemStone (continued)	• Smalltalk-like user interface • Class and code browsers • External Smalltalk query language • Password security • GeODE development environment: - multimedia forms package - visual programming environment - visual schema designer • Optimized object query language	• Sun 3 and 4 • DecVAX (VMS) • IBM RS 6000 • DecStation • Data General Aviiion • Sony News • IBM MVS • IBM PC • Mac II • Min. RAM requirements: (most platforms) 6MB	\$20,000 for four-user development license; GeODE: \$5,000 for four-user license	IBM business partner. GemStone training and consulting available through Booz Allen. Servio and ParcPlace Systems are jointly integrating GemStone with ParcPlace's ObjectWorks/C++ application development tool.
IDB Object DB (continued)	• Portable UI, interactive browser (applications can be built with or without IDB UI): X11, NextStep, MS Windows, Mac, Unix termcap and terminfo, Apollo Domain OS GPR	• IBM PC (DOS, Windows) • Mac • NeXT • Sun 3, 4, and SPARCstation • HP/Apollo Domain OS (all 680x0) • HP/UX (all) • Min. RAM requirements: 2MB (4MB recommended)	\$2,500 PC and Mac; \$3,500 NeXT; \$6,000 Unix/Other. All single user licenses \$200 single runtime	\$99 IDB introductory package available. Includes working application running under IDB browser in Windows or Mac; complete IDL and C source for application; \$99 credit towards purchase of full system. Supports exception handling and includes extensive error detection and repair.
ITASCA (continued)	• OSF/Motif Dynamic Schema Editor • OSF/Motif Active Data Editor • OSF/Motif DBA tools • Query by example • Security authorization at the DB, class, instance, attribute, and method levels	• Sun 3 and 4 • IBM RS 6000 Apollo • DecStation (Ultrix) • Silicon Graphics • Min. RAM requirements: 16MB	\$3,995	Commercial version of the Orion DB developed by MCC
O₂ (continued)	• O₂ Look: X/Motif GUI with DB and schema browsers and multimedia editors • O₂ SQL: extended SQL object query language • O₂C: "4GL" with direct access to C libraries • Access codes and password security	• Sun 3 and 4 • HP 300/400 and 700 • IBM RS 6000 (announced for 1992) • DecVAX (announced for 1992) • Min. RAM requirements: 8MB	\$15,000- \$30,000	Commercial version developed from the Altair research project

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Table 1, continued — Commercial Object-Oriented Database Management Systems

OODBMS Products and Vendors	Data Management			Storage Management
	Implementation Language	DMML	Data Modeling Support for:	Support for:
Objectivity/DB (version 1.2) Objectivity Inc. 800 El Camino Real Menlo Park, CA 94025 (415) 688-8000	C/C++	Extended C++	- C or C++ - Composite and objects - Referential integrity - Schema protection - Multiple inheritance - Strong type checking - Multimedia support - Object naming and multiple name scopes	- Short/long transactions - Transactions serialized - Hierarchical locking - Elaborate versioning - Multiple reader/one writer - Index management for collection of complex values - Object clustering - Multiple DBs supported
ObjectStore (version 1.2) Object Design, Inc. 1 New England Exec. Park Burlington, MA 02154 (617) 270-9797	C/C++	C, C++, or Extended C++	- C++ parameterized classes - Limited schema evolution facilities - Limited, composite objects - Multiple inheritance - Strongly typed - C++ utility classes - Multimedia support	- Nested transactions to any depth - Read-only update - Persistent and nonpersistent - Two locking modes: read, write - Two-phase commit - Long and short transactions serialized - Elaborate versioning - No change notification
ONTOS DB (version 2.2) Ontos Inc. (formerly Ontologic) 3 Burlington Woods Burlington, MA 01803 (617) 272-7110	C++ (2.1)	C++ (2.1)	- Hybrid OO programming system that relies heavily on C++ - Strongly typed - Multiple inheritance - Library of C++ utility classes - Limited schema evolution facilities - No multimedia support	- Nested transactions - Persistent and non-persistent transactions serialized - Four locking modes: read, write, write-intent, and no lock - No version management - Doesn't support interclient communication - Limited change notification
Statice Symbolics 8 New England Exec. Park Burlington, MA 01803 (617) 221-4000	Lisp	Common Lisp with Flavors and CLOS	- CLOS object model - Multiple inheritance - Schema evolution facilities	- Nested transactions - No version management - No change notification
Versant ODBS Versant Object Technology Corp. 4500 Bohannon Drive Menlo Park, CA 94025 (415) 329-7500	C/C++ (2.0)	- C/C++ (2.0/2.1) - Interfaces to C - Smalltalk	- C or C++ - Limited composite objects - Multiple inheritance - C++ class libraries - Schema evolution facilities at leaf node level - No multimedia support	- Short and Long transactions - Elaborate locking - Flexible concurrency control without serializing - Transactions serialized - Elaborate versioning - Limited change notification - Two-phase commit - Application can be converted to multiple DBs at any time

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Table 1, continued — Commercial Object-Oriented Database Management Systems

Product	Interface Management	Hardware Platforms Supported and RAM Requirements	Pricing	Comments/Fielded Applications
Objectivity/DB (continued)	• OSF/Motif • Query language using iterator constructs • 4GL planned • Password protection • Password schema protection	• Sun 3 and SPARCstation • HP 9000 • IBM RS 6000 • DEC RISC (VAX, VMS, Ultrix) • Silicon Graphics • Sony News • Min. RAM requirements: 8MB	\$3,000-\$30,000	Joint integration efforts with HP SoftBench, and CenterLine Software's ObjectCenter C++ programming environment. Fielded commercial applications include: Valid — ValidFrame EDA design manager; Gain Technology — Computer-based training application; PiE Design — High performance ECAD application
ObjectStore (continued)	• Graphical browser with schema designer, X/Motif • Custom query language • 4GL capability • Password security	• IBM PC (Windows 3.0) • Sun 4 (Sun/OS) • AIX RS/6000 • HP 9000 (HP/UX) • Min. RAM requirements: 8MB for Unix; 6MB for Windows 3.0	\$2,500-\$11,000	Lucid is using a runtime version of ObjectStore for the DB/Repository in its new C++/C programming environment — "Energize." Also compatible with Centerline's C++ programming environment and ParcPlace's ObjectWorks. Object Design reps. say "Company has installed base of over 135 separate installations with over 2,000 licensed seats."
ONTOS DB (continued)	• Graphical schema design in X/Motif - allows browsing, type creation and definition, instance creation, and C++ code generation • GUI Builder for ONTOS applications • No security facilities • Object SQL	• IBM 386/486 PC (OS/2) • Sun 3 and 4, SPARCstation • DECStation • IBM RS 6000 • HP/Apollo • Min. RAM requirements: 4MB for PCs; all others 8MB (16MB recommended)	\$10,000-\$50,000	Formerly Ontologic. Formerly sold VBase. ONTOS is compatible with CenterLine Software's (formerly Sabre) ObjectCenter C++ programming environment. Fielded applications include: International Software Systems' Ada CASE Tool; Accurate Information Systems' document storage in its CALS tools; Canadian government's geographic information system
Stattice (continued)	• Graphical browser GUI • Custom Lisp-based query language • Password protection	• Symbolics Lisp Machine • SunSPARCstation (with accelerator board) • Mac II (with accelerator board)	\$10,000 for single user; \$40,000-\$50,000 site	Fielded applications in use at Houston Lighting & Power and Lufthansa Airlines
Versant ODBS (continued)	• X/Motif with browsing similar to Smalltalk • Query management via select method • 4GL capability • Group level security • Object SQL	• Sun 3 and 4 • IBM RS 6000 • Sequent multiprocessor • DecStation 310/5100 • HP 9000 400/700 • Silicon Graphics • Min. RAM requirements: 12MB	\$6,000 single user	Versant is integrated with: CenterLine Software's C++ programming environment; Facets; Tigre Object Technology's interface development tool. Also working with Sequent Computer and ParcPlace on version of Versant for large-scale ODB applications. Rational uses Versant for object storage in the Rational Rose OOA&D tool, a process completely hidden from the user.

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capabilities, ITASCA is quite a bit better than any of its competitors. Lisp, however, can be difficult to integrate into conventional environments, and only a very limited number of programmers are sophisticated enough to take advantage of the dynamics provided by a Lisp environment. Other, earlier vendors that offered Lisp-based OODBMSs are already in the process of converting to C++. It will be interesting to see if Itasca can sell the power of Lisp better than those earlier vendors.

O₂ (version 3.2)

O₂ is sold by O₂ Technology, a company headquartered in Versailles, France. The US office is located in Cambridge, Massachusetts. O₂ is the commercial version of an OODBMS that resulted from the Altair research project, a consortium that was founded in 1986 and included INRIA, Siemens-Nixdorf, Bull, CNRS, and the University of Paris. The consortium disbanded in September 1991 and established O₂ Technology to market the resulting OODBMS product.

O₂ is written in C and C++ (version 2.1). The DMML environment is written in O₂'s own language, CO₂, and functions like an extended C++ environment. The object model is strongly typed and provides multiple inheritance and good support for complex object types. Persistent and nonpersistent transactions are serialized. O₂ provides two locking modes.

The O₂ interface uses X/Motif and features DB and schema browsers. A 4GL language, O₂C, is available. Queries are made via O₂ SQL, and access codes and password security are provided. O₂ is available on a variety of machines (see Table 1) and costs between \$15,000 and \$30,000.

O₂ offers a good mix of C++ efficiency and extensions to give it more flexibility.

Objectivity/DB (version 1.2)

Objectivity/DB is sold by Objectivity Inc., which is located in Menlo Park, California. Objectivity/DB is written in C and C++. The DMML environment is an extended version of C++.

The Objectivity/DB object model is an extended version of the C++ model. Objectivity/DB offers strong type checking, multiple inheritance, and composite and complex objects. It does not support dynamic schema modifications. Objectivity/DB allows short and long transactions and hierarchical locking. Transactions are serialized. The system provides elaborate, object-level versioning. The Objectivity/DB interface is OSF/Motif. Objectivity/DB features a query language based on iterator constructs. Password protection is provided. No 4GL is available at the moment, but one is planned.

Objectivity/DB is available on a wide variety of platforms (see Table 1). The cost of one unit for a Sun 3 is \$3,000. Objectivity has joint product integration efforts underway with HP (SoftBench) and CenterLine (ObjectCenter, formerly Sabre Software). Objectivity/DB has been used in several fielded commercial applications, e.g., Valid's Valid-Frame EDA design manager. Gain Technology also sells a computer-based training application running on Objectivity/DB.

Objectivity seems to be aiming at a reasonable mix of C++ efficiency and extensions to give it more flexibility.

ObjectStore

ObjectStore is sold by Object Design, which is located in Burlington, Massachusetts. ObjectStore is written in C and C++ (version 2.1), and its DMML is an extended C++ environment. The object model supports parameterized classes and multiple inheritance. C++ utilities are also provided. ObjectStore offers only limited composite objects and schema evaluation facilities.

ObjectStore supports nested transactions to any depth. It features both persistent and nonpersistent objects and two locking modes. Transactions are serialized. ObjectStore supports elaborate versioning, but there is no change notification. The end-user interface is provided by X/Motif and includes database browsers. ObjectStore offers a custom query language, but no 4GL capabilities. It does feature password security.

ObjectStore runs on Sun 3s and 4s. A single unit costs \$25,000. ObjectStore seems to be a nice mix of C++ efficiency and extensions to give it more flexibility.

ONTOS DB (version 2.1)

ONTOS DB is sold by Ontos, Inc. (formerly Ontologic, Inc.), which is located in Burlington, Massachusetts. ONTOS DB is written in C++ (version 2.1), and C++ is used in the DMML environment. ONTOS DB supports multiple inheritance and provides limited support for more complex data types. It does not support composite objects or dynamic schema revision.

ONTOS DB allows nested transactions to a depth of 127 levels, and persistent and nonpersistent transactions are serialized. It features four locking modes and limited change notification. The system does not support version management or interclient communication. The ONTOS DB user interface is provided by X/Motif. The user environment allows browsing, type creation and definition, instance creation, and C++ code generation. ONTOS DB provides an object SQL query facility. It does not yet have a 4GL capability, although one is under development. ONTOS DB does not provide security facilities.

ONTOS DB runs on several platforms (see Table 1). The cost for a single unit for a Sun 3 is \$10,000. Prior to introducing ONTOS DB, Ontos Inc. sold a product called VBase. International Software Systems Inc. uses ONTOS in its Ada CASE tool, Accurate Information Systems, Inc. uses ONTOS in one of its CALS tools to store document components, and the government of Canada uses ONTOS in a geographic information system developed by McDonald Dettwiler.

Ontos' product relies heavily on C++ for efficiency and, as a result, offers less flexibility than some of the products that have done more to extend C++.

Statice

Statice is sold by Symbolics, a Lisp hardware vendor that has moved into software. Statice is a

Lisp system designed to interact with Lisp applications. Its DMML is a common Lisp environment. Statice provides complex objects, complex multiple inheritance, and extensive schema evaluation and modification facilities. It supports nested transactions and versioning, but not change notification. Statice features extensive graphical browsers, a custom Lisp-based query language, and password protection. Statice is designed to run on a Symbolics machine and will run on other machines set up for Lisp processing (see Table 1). A single copy sells for \$10,000. At least two fielded applications developed in Statice, one at Houston Lighting & Power and another at Lufthansa Airlines, have received some attention in the press.

Statice is an early version of an OODBMS designed to support developers working on Lisp machines. As such, it is aimed at a very narrow niche; Lisp-based OODBMS products like ITAS-CA are more modern and are designed to run in Unix and client-server environments.

Versant ODBMS (version 1)

Versant ODBMS is sold by Versant Object Technology, which is headquartered in Menlo Park, California. Versant ODBMS is written in a combination of C and C++ (version 2.0). The DMML environment is essentially a C++ environment, although the product interfaces to C and Smalltalk applications.

The object model supports multiple inheritance and limited composite objects. Schema evolution is supported at the leaf node level. C++ class libraries are provided. Versant ODBMS allows short and long transactions and supports elaborate locking. Transactions are serialized. The system features change notification and elaborate versioning. Versant ODBMS provides an X/Motif user interface with browsing capabilities similar to those provided by Smalltalk. Queries can be made via an Object SQL language; management is via select method. Versant offers a nice combination of C++ efficiency and extensions to give it more flexibility.

Versant ODBMS runs on a variety of platforms (see Table 1). The price for a single unit on a Sun 3 is \$6,000. Versant ODBMS is integrated with CenterLine C++, Facets, and Tigre Object Technology. Another Versant-based product is Rational Inc.'s Rational Rose (see related story, p. 13).

In addition to those mentioned above, a number of other OODBMS products are currently available. POET, for example, is an OODBMS that runs in DOS under Windows, in UNIX, or on the NeXT machine. POET starts at \$399 and runs up to \$2,999 on HP's Unix machine. POET is designed to allow C++ programmers to add persistence to their C++ applications. Our description makes POET sound rather limited, but it's certainly inexpensive. (For more information on POET, contact BKS Software, One Kendall Square, Suite 2200, Cambridge, MA 02139, USA; (617) 621-7047, Fax: (617) 621-7097.)

Hewlett-Packard has also announced an OODBMS, OpenODB, which runs on top of HP's Allbase relational database. We don't have enough information to discuss it in this review, but we'll certainly consider it in future discussions of OODBMSs.

Comparing and Contrasting

It will be some time before we can identify those companies having the right combination of skill and resources to survive during the next three

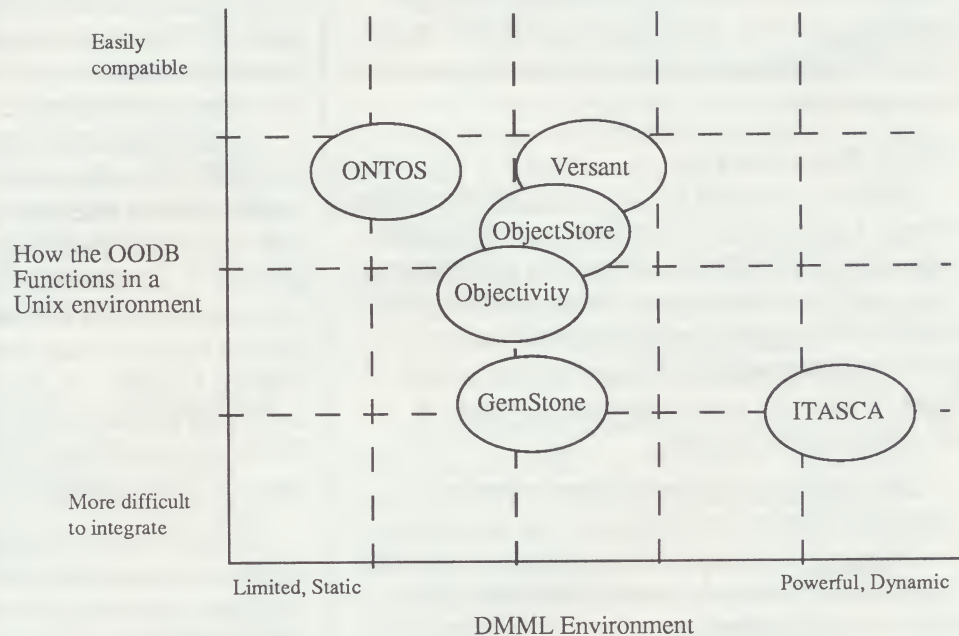


Figure 2 — A subjective analysis of some of the major OODBMS products.
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to five years it will take before any of them becomes either secure or profitable.

All the vendors are in the process of changing their offerings as they discover new users who desire specific features, or as their competitors offer features that seem to interest customers. There are many factors we could consider in comparing these products. Figure 2 provides a subjective comparison: on the horizontal axis we show a continuum running from a weak, static object model to a rich, dynamic model. On the other axis we have a continuum that runs from products that use symbolic languages (and are typically harder to integrate into conventional environments) to tools that use very standard C++ formats (and are relatively easy to integrate into conventional environments). Notice that we have limited our vertical continuum to Unix environments. We didn't include mainframe environments, as no existing OODBMS products function efficiently on centralized, mainframe-oriented environments. The closest they come is providing links to relational

databases. The successful OODBMS products will move in this direction in the course of the next few years, which is just another way of saying that the current products are only the first generation and will change quickly as time passes.

We have placed some of the best-known tools on this matrix and we will explain our reasoning below. Our placements are based on reading documentation and on seeing demonstrations, not on detailed hands-on evaluation. Also keep in mind that there are other dimensions that you could consider, for example, the developer interface and the end-user interfaces.

The most powerful and dynamic OODBMS at this point in time is ITASCA. When you put together a list of all of the things you would like an OODBMS DMML to do, you virtually define ITASCA. Of course its power and flexibility come from the fact that ITASCA is written in Lisp and can take advantage of the symbolic, interpreted nature of the language. This, in turn, means that most programmers won't begin to understand what you can do with ITASCA, and it suggests that there will be some compatibility problems if you try to integrate an ITASCA database into a conventional Unix environment.

In the worst case, ITASCA will face the problems faced by the Lisp-based expert systems tools in the early 1980s. They will be more powerful and flexible than any of their competitors written in conventional languages, but they will find themselves limited to a niche market composed almost entirely of Lisp programmers. On the other hand, Lisp developers have learned a lot about how to integrate symbolic languages and conventional languages, and the current versions of Lisp are much more efficient than the Lisp compilers of the early 1980s. Moreover, ITASCA has already been adding C to its product in order to facilitate better compatibility. In the best case, the client-server environments and the demands of powerful CAD and CASE applications will demand the power of a product like ITASCA, and companies will be willing to climb the rather steep learning curve in order

to gain the benefits it offers. This didn't happen in the case of the Lisp-based expert systems products. We'll see if the market has grown more sophisticated about the uses of Lisp and is willing to accept Lisp-based OODBMS products over the course of the next couple of years.

If the OODBMS market were to follow the same evolutionary path that the expert systems-building tools market did in the 1980s, you would expect that the Lisp-based products would have only very limited success, and the C and C++ products that offered less power but greater compatibility with existing mainframe-oriented IS environments would be the most successful. Of course, the world never exactly repeats itself. The Lisp-based expert systems vendors tried to convince IS people to consider workstations and client-server solutions, but they were too early. Hardly anyone in the commercial world had heard of Lisp when the expert systems products were first introduced in 1984. Moreover, very few companies were doing CAD, CASE, or multimedia types of applications. Today, most IS people are still oriented towards mainframes, COBOL, and centralized networks, but they are much more open to alternatives. Besides, for the next few years, most of the OODBMS vendors will be selling to CAD and CASE developers rather than IS departments. And some of them will be selling to companies creating large expert systems.

If you know Lisp and want to explore what a really powerful OODBMS can be like, consider ITASCA. Otherwise, you're left trying to decide between systems derived from Smalltalk, C++, and various extended C++ systems. At the moment, there's no clear winner.

On the left side of the horizontal axis is ONTOS, which seems to be more limited to C++ than some of the other products. GemStone (which is based on Smalltalk) is more dynamic than most of the C++ products, but lacks features like multiple inheritance. A number of OODBMS products that extend C++ in various ways fall in the center.

On the vertical axis we consider how easy it would be to integrate the OODBMS tool into a conventional Unix environment. There are many aspects to integration; we are making a very broad generalization in talking about it as if it were a single variable that could be mapped onto a single axis, so we repeat that ours is a pretty subjective measure. As you can see, we think that there's a general correlation between power and flexibility and integration difficulties and vice versa. We expect that the market will settle on the middle ground, on products that have DMMLs based on extended versions of C++. They will provide more flexibility than those based on too close an approximation of straight C++, but they will not provide the flexibility of Lisp-based products. On the other hand, they will be easier to integrate into conventional environments. When we do a detailed review of the OODBMS products again, in about a year, we expect to provide a much more detailed checklist of features based on criteria derived from companies' actual experience fielding OODBMS applications. At that time we'll do a weighted comparison of the products and get a lot more specific about ranking their utility and efficiency.

Summary

One thing even a casual reader will notice is that these products are not being sold by large, well-known computer software vendors. These are new companies pioneering a new approach to database development. Another point worth noting is that none of these products can reside on a mainframe; their vendors are all banking on the widespread use of client-server systems.

It's very early in the development of OODBMSs. Most Fortune 500 companies are simply conducting research at this time. A few have started using OODBMS products for very limited applications like office information systems and CAD systems, but no large company we know of has made a major commitment to any one OODBMS company. Thus, we assume that it will be two or three years before any of these companies begins to establish a real dominance in this new market.

Our guess is that most of the OODBMS vendors are earning somewhere between \$3 million and \$6 million a year in sales. If we assume that six to eight OODBMS vendors made that much money in 1991, then the total direct US market for OODBMS products was probably somewhere around \$40 million — not very much, even in a recession year. Some analysts have placed the OODBMS market much higher — over \$100 million. (We'll consider all this in more detail in the next issue of *OOS*, when we review the financial condition of the entire OO market.) At this point, we want to remind our readers that there are no really dominant players as yet, and that no one is making enough money to assure that they will be around in two years time.

All of the vendors will keep modifying their products and their marketing strategies during the course of the next two to three years and the products that emerge in the course of that period will be very different from the current offerings. The successful OODBMS companies that emerge in three to five years will be those that figure out how to combine technical know-how, good marketing, fast response times, financial resources, and good management. It's too early for corporate clients to try to pick winning vendors. The best the well-advised user company can do is try one or more products to learn about the technology and get some idea of what kind of product it will eventually want to commit to when the products become more sophisticated and the vendors become more stable. It's frankly too early to try to choose the best, or even the three or four that are most likely to survive.

As we mentioned in the January issue of *OOS* (where we reviewed OODBMS technology in a more general way), relational database vendors will be extending their products to handle objects. In addition, most CASE repositories can be thought of as extended relational databases. Thus, although we have discussed OODBMS products as if they made up a niche and were all competing with each other, in fact, the best of the OODBMS products will soon be competing with extended relational databases, and perhaps even with CASE repositories. All

three aim to offer the same functionality — namely, the ability to store objects and other complex data types. In addition, all three types of products will invariably get drawn into the struggle between centralized, mainframe-oriented networks and newer client-server architectures, many of which will be designed with object-oriented techniques. In other words, the most successful product will not succeed on its own merits alone, but on how well it is able to mesh with other products and general industry trends that will be played out during the next three to five years.

Hardware vendors have usually let smaller companies pioneer new database technologies and then later offer their own database systems when the market becomes more mature. It has certainly happened in the relational database market and we expect that it will happen in the OODBMS market as well. Thus, we expect that some of the most successful of the current crop of OODBMS companies will be acquired by hardware vendors who will revise their products and offer them under their own name at some point in the late 1990s. It's just another way of saying that the OODBMS market is still young.

If we were asked for our personal advice, we'd probably suggest that you experiment with two or three different products and put off any major commitment. But do begin to learn about the technology. There will be a period yet when most companies will continue to rely on relational databases, and there will be a longer period when companies will rely on extended relational databases, but the age of real OODBMSs has begun, and by the end of this decade every major corporation will have a rapidly growing need for databases that can handle complex data types. Before the end of the decade, most major companies will realize that they need more than the patched-up relational databases will be able to provide and they will begin converting to OODBMS products in a serious way. The time to start learning about how to use OODBMS products is now.

OOS will be publishing a list of all of the fielded OODBMS systems that we know about later this year. If any reader knows of such a system, we would certainly appreciate your letting us know about your experience. Please contact Curt or Paul at (415) 861-1660.

TRENDS AND NEWS BRIEFS

ParcPlace and Rational to Add Compatibility to C++ Programming Environment and Object-Oriented Analysis and Design Tool

ParcPlace, vendor of the ObjectWorks/C++ programming system, and Rational, seller of the object-oriented analysis and design (OOA&D) tool Rose, have announced plans to make their systems compatible.

The agreement between ParcPlace and Rational will help streamline OO development by allowing developers to perform analysis and design using Rose and then translate their designs into C++ application code using ObjectWorks/C++ programming language facilities. In addition, current ObjectWorks/C++ users will be able to import exist-

ing C++ code into Rose so they can review and update their application design.

The two products will remain separate, but will enable users with both to design on one and generate code with the other.

Presently, Rose helps facilitate the development and documentation of the OOA&D process by allowing developers to diagram OO applications (using Booch notation) and then print out the desired documentation. However, it provides no language facilities for writing code. ObjectWorks, on the other hand, supports OO development with editors, class libraries, and a programming language environment, but it provides very little in the way of supporting OOA&D. Compatibility be-

tween ObjectWorks and Rose should help automate the process of moving from design to code.

We have argued for some time that in the long run, OO application developers would prefer to work in an "OO CASE tool" environment complete with OOA&D capabilities as well as facilities for code generation. Although ParcPlace and Rational's announcement is not offering such a fully integrated environment — rather, only compatibility between their respective systems — it is a step in the right direction.

ObjectWorks/C++ and Rose operate in Unix environments. Both intend to support IBM's Software Development Environment Work-Bench/6000.

For more information, contact: ParcPlace Systems, 1550 Plymouth Street, Mountain View, CA 94043, USA; (415) 691-6700; or Rational, 3320 Scott Blvd., Santa Clara, CA 95054, USA; (408) 496-3700.

Lucid Announces Energize; Uses ObjectStore for DB/Repository

Lucid announced the release of the Energize C++/C Programming System for Sun SPARCstations. Written in C++, Energize is designed for C++ and C users and is well-integrated with the standard Unix programming environment. Energize includes various features that facilitate OO development — such as incremental compilation and linking to decrease the amount of time a programmer must wait when making changes to a program — and facilities that allow developers to navigate easily through an entire program in order to understand code structure and isolate problems.

Of particular interest is Lucid's use of Object Design's ObjectStore OODBMS. Included in the Energize programming system is a run-time version of ObjectStore OODBMS that functions as the system's DB/Repository.

We recently spoke with the folks at Lucid and discussed their choice of an OODBMS. It seems

that during early work on the development environment, the programming team first experimented with a traditional record-and-query-based DB in an attempt to implement persistence with a "home grown" object-based system. However, they quickly became aware that the performance of the file interface was not adequate for the environment's essential requirement — the fast retrieval and update of many small and tightly connected objects. For this reason and others, Lucid decided on an OODBMS implementing a fast navigational object retrieval scheme rather than a query-based scheme. ObjectStore's Object Design fit the bill because it offered Lucid the fast page-based, rather than record-based, implementation of data retrieval and update they desired.

The use of an OODBMS with the Energize Programming System provides two primary benefits. First, it serves as a long-term storage mechanism for all the information about the program under development that is gathered by the various tools. The OODBMS is frequently updated so that if a machine crashes or users simply shut down for the day, they can restart where they left off. In most systems, the programmer has to restart and recreate lost information in order to return to the previous state of the program.

A second benefit of using an OODBMS as opposed to a standard file system or RDBMS is that it allows for very fast access to objects acquired by the tools and passed on to the server. Along with other performance improvements, this provides the user the ability to navigate through very large programs with little or no performance degradation.

Lucid's use of ObjectStore is a good example of a growing trend in which vendors of OO development environments/tools integrate their systems into or alongside OODBMSs (as revealed in Table 1 of our lead article). However, outside of Rational (which has developed its OOA&D Rose on top of Versant), most vendors have up until this time only provided compatibility for their OO environments with OODBMS vendors' products.

Energize is available for SPARCstations and will be ported to other Unix workstation platforms over the next 12 months. The price for a 5-person workgroup version is \$16,250; a 10-person

workgroup is \$29,750. Additional discounts are available.

For more information, contact: Lucid Inc., 707 Laurel Street, Menlo Park, CA 94025, USA; (415) 329-8400.

CALENDAR

The following conferences and seminars should be of interest to those involved in the commercial application of object-oriented technologies. ** Indicates that the conference will be a major gathering of OO people and a good place to get an overview of the field.

1992 North America

February 18-22. **CASE World '92 Conference & Exposition.** Santa Clara, California. Sponsored by *Information Week*, *Dr. Dobbs' Journal*, and DCI. Contact: DCI, 204 Andover Street, Andover, MA 01810, USA; (508) 470-3880, Fax: (508) 470-0526. *Will feature workshops and seminars on all aspects of CASE development, including Open Systems, OOP, C++ development, and more.*

February 23-28. **Software Development '92.** Santa Clara, California. Contact: Software Development Conference Group, 600 Harrison Street, San Francisco, CA 94107, USA; (415) 905-2741, Fax: (415) 905-2222.

March 23-26. **DB/Expo '92.** San Francisco, California. Contact: Pat Lucas, Lucas Communications, 289 So. San Antonio Road, Ste. 204, Los Altos, CA 94022, USA; (415) 941-8440, Fax: (415) 941-2066. *Focus will be on the application of database and associated technologies, CASE, distributed environments, OOPS for solving corporate computing problems. Speakers include: Phillipe Kahn, President, Borland International; Charles Bachman, Chairman, Bachman Info Systems; Phil Neches, Senior VP, NCR Corp.; and Colin White, Conference Coordinator and President, Database Associates. Will also feature product vendors.*

April 12-15. **Borland International Developers Conference.** Monterey, California. Contact: Bor-

land International Developers Conference, CT Meeting Planers, Inc., 731 Main Street, Ste. C3, Monroe, CT 06468, USA; (800) 942-8872 or (203) 261-6227, Fax: (203) 261-3884.

April 13-16. **SCOOP West.** Santa Clara, California. Contact: SIGS Conferences, 588 Broadway, Ste. 604, New York, NY 10012, USA; (212) 274-9135.

May 4-5. **The Pen-Based Computing Conference.** Boston, Massachusetts. Contact DCI, 204 Andover Street, Andover, MA 01810, USA; (508) 470-3880, Fax: (508) 470-0526. *Will feature products, market trends, hardware/software concerns, and development efforts. Sponsored by Digital Consulting International.*

May 4-6. **ICOOMS '92 International Conference on Object-Oriented Manufacturing Systems.** Calgary, Alberta, Canada. Sponsored by the University of Calgary and the Society for Computer Simulation. Contact: Douglas Norrie, Conference Chairperson, Division of Manufacturing Engineering, Faculty of Engineering, University of Calgary, 2500 University Drive NW, Calgary, AB T2N 1N4, Canada; (403) 220-5787, Fax: (403) 282-8406.

May 26-27. **OMG Technical Committee Meeting (and Board of Directors Meeting).** Austin, Texas. Contact: Object Management Group, (508) 820-4300, Fax: (508) 820-4303.

July 6-10. **CASE '92**, (Fifth International Workshop on CASE). (Will be held in conjunction with the CASE '92 Tools Forum). Montreal, Quebec, Canada. Contact: Homa Taraji, Chairman, CASE '92 Tools Forum, The Aerospace Corp., M8-026, P.O. Box 92957, Los Angeles, CA 90009, USA; (213) 336-3450, Fax: (213) 336-3538. *Will feature CASE re-*

searchers, vendors, and users interested in the advancing CASE industry.

**** July 20-23. Object World.** San Francisco, California. Sponsored by the Object Management Group. Contact: Object World, c/o World Expo Corp., P.O. Box 9107, Framingham, MA 01701-9107, USA; (800) 225-4698 or (508) 879-6700, Fax: (508) 872-8237. *Will feature seminars and major vendors. Focus will be on object technology as the key to competitive advantage in the 1990s.*

**** October 18-22. OOPSLA '92** (Seventh Annual Conference on Object-Oriented Programming Systems, Languages, and Applications). Vancouver, British Columbia, Canada. Sponsor: ACM. Contact: OOPSLA '92, Tektronix, M/S 47-786, P.O. Box 500, Beaverton, OR 97077, USA; (503) 627-3045.

1992 International

March 18-19. OMG Technical Committee Meeting. Belfast, Northern Ireland. Contact: Object Management Group, (508) 820-4300, Fax: (508) 820-4303.

March 30-April 2. TOOLS Europe '92 (Technology of Object-Oriented Systems & Languages). Dortmund, Germany. In USA contact: Burghardt Tendrich, TOOLS Europe '92, 270 Stork Road, Ste. 7, Goleta, CA 93117, USA; (805) 685-1006, Fax: (805) 685-6869. In Europe contact: TOOLS/SQL, 104 rue Castagnary, 75015 Paris, France; +33 1 45 32 58 80, Fax: +33 1 45 32 58 81. *Topics will include: OO analysis and design, management and training issues, experience report, and others.*

May 11-13. Object Expo. Munich, Germany. Contact: SIGS Conferences, 588 Broadway, Ste. 604, New York, NY 10012, USA; (212) 274-9135.

June 16-18. Software Development '92 (The Software Tools Show). Wembley, UK. Contact: Blenheim Online, Blenheim House, Ash Hill Drive, Pinner, Middlesex HA 2AE, UK; +44 81 868 4466, Fax: +44 81 866 5691.

June 29-July 3. ECOOP '92. Utrecht, The Netherlands. Sponsors include the Software Engineering research Center, DND, George Heeg Smalltalk-80-

Systems, Austrian Computer Society, Swiss Computer Society, and the Object Management Group. Contact: Gert Florijn, Software Engineering Research Center, P.O. Box 424, 3500 AK Utrecht, The Netherlands; +31 30 322640, Fax: +31 30 341249.

October 28-30. Third Eurographics Workshop On Object-Oriented Graphics. Champéry, Switzerland. Sponsored by the Université de Genève, Centre Universitaire d'Informatique. Contact: Eurographics Workshop on Object-Oriented Graphics, Centre Universitaire d'Informatique, 12 rue du Lac, CH-1207 Geneva, Switzerland; +41 22 787 65 86, Fax: +41 22 735 39 05.

**** Dec 7-11. Toulouse '92** (Fifth International Conference on Software Engineering & Its Applications). Sponsored by Cigref, SEE, and Syntec-Informatique. Contact: EC2, 269 rue de La Garenne, 92024 Nanterre Cedex, France; +331 4780 7000, Fax: +331 4780 6629.

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